

Quarterly Progress Report

October 1 – December 31, 2005

BOR Agreement 1425-05-FG-10-1188

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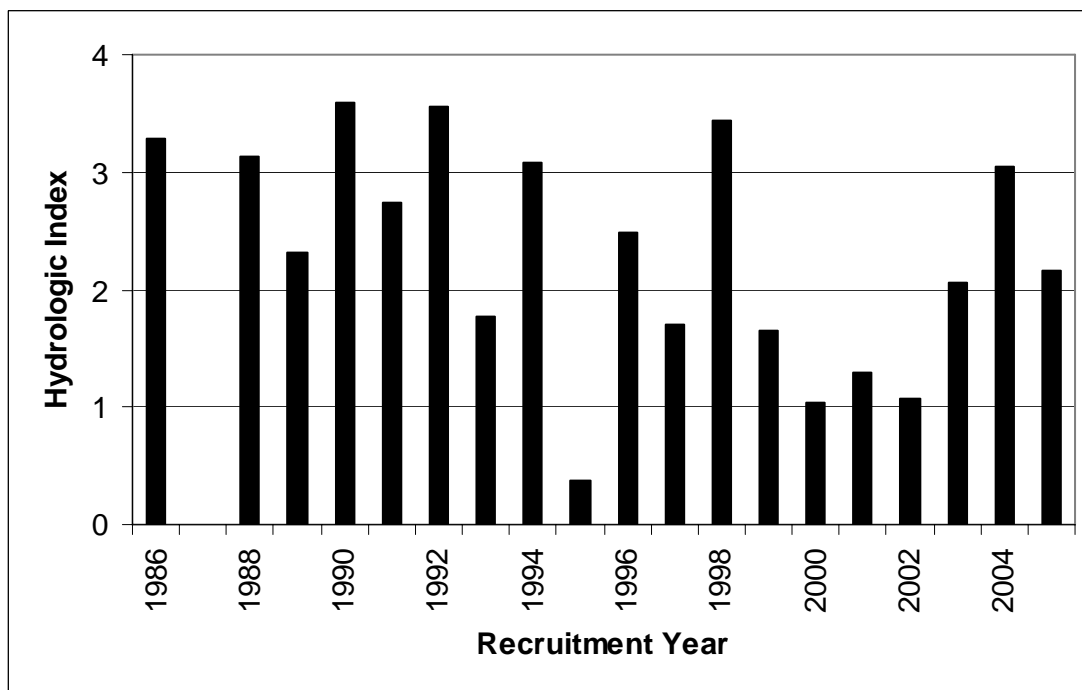
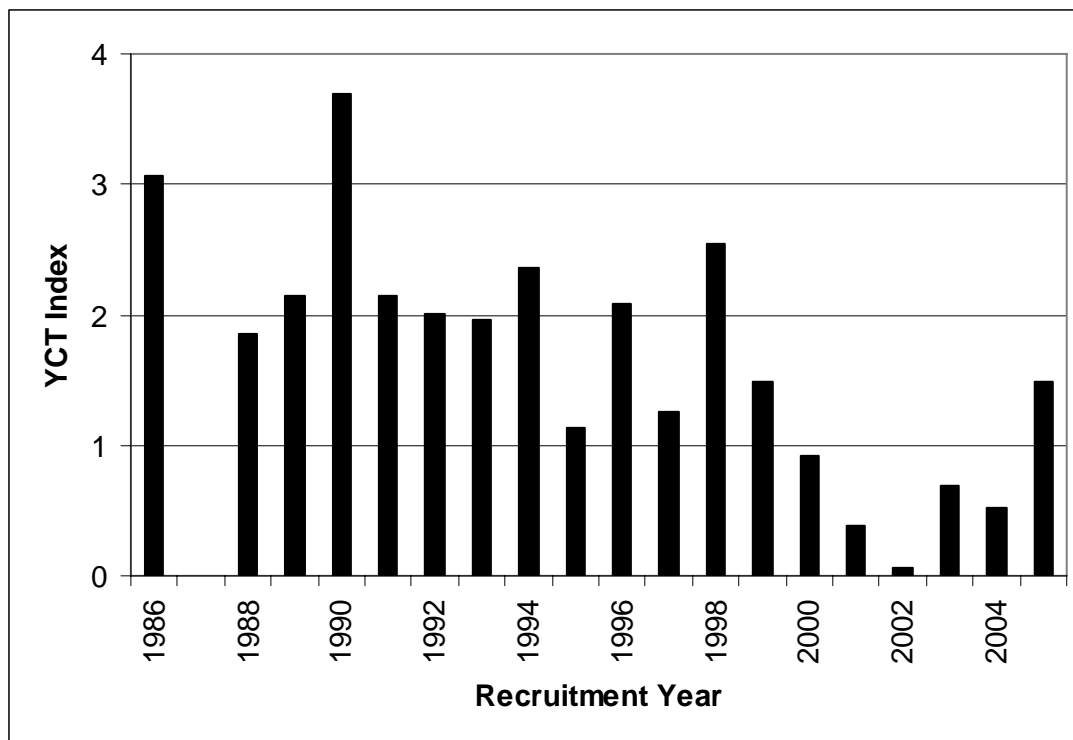
Bureau of Reclamation implemented Ecologically Based System Operations (EBSM) on the South Fork Snake River during winter 2003-2004. IDFG began biological monitoring of Yellowstone cutthroat trout during the same time period. This quarterly progress report summarizes activities conducted during the fourth quarter of 2005, which is the first quarter of this new grant agreement.

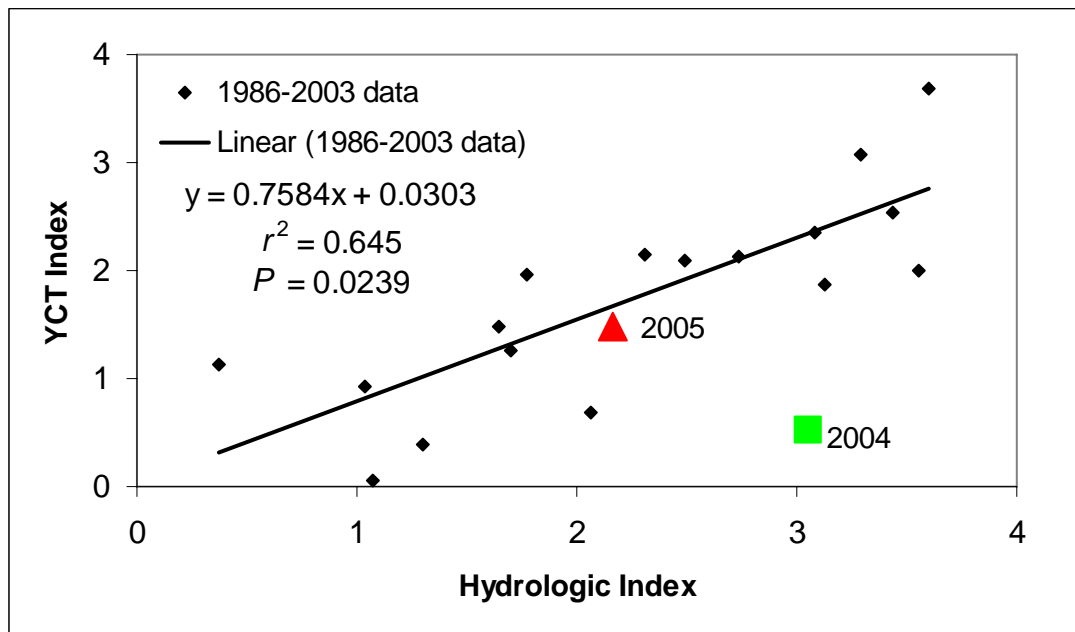
An estimated 5,000 rainbow trout were harvested in 2003 compared to 1,000 in 1996. It is likely that significantly more rainbow trout will be harvested this year with our continued information and education campaign and the major regulation changes that began in 2004. During this quarter, 34 flights were completed and 553 anglers were interviewed to complete the year-long creel survey. Data are currently being entered and will be analyzed for the next quarterly report.

Annual population monitoring using electrofishing was completed at the Conant reach (upper South Fork above Heise) in October. For age 1 and older fish, we observed a 38% increase in cutthroat trout abundance and a 21% decline in rainbow trout abundance. These population trends are headed in the right direction, and rainbow trout are now around their mid-1990s level. However, cutthroat trout are still quite depressed throughout the river - probably due to drought. As reported last quarter, the cutthroat trout estimate at Lorenzo is the lowest recorded since 1987, and the Conant estimate is second lowest since 1986 - only last year being lower.

Radio telemetry transmitters (or tags) were planted in 20 rainbow trout redds last April and May to evaluate redd scouring from the 2005 freshet (15,000 cfs on 15 June). In November, all tags except one were retrieved and gravel movement was evaluated. No tags had moved and gravel movement was minimal. Based on these results, the 2005 freshet did not significantly alter rainbow trout redds in the South Fork. The missing tag – planted in the Rainey Creek side channel – probably malfunctioned.

A major objective this quarter was to evaluate the 2004 freshet (18,960 cfs on 23 May) in terms of fish recruitment to the South Fork. Two indices were developed to better present results (see below). The Yellowstone cutthroat trout (YCT) index was developed using rainbow and cutthroat trout recruitment parameters measured at the Conant electrofishing reach. The hydrologic index was developed from a set of eight variables describing hydrologic conditions as measured at the Heise gage. Graphical depiction of both indices for recruitment years through 2005 are shown in the following figures. The 2004 recruit class (i.e. yearlings measured in the fall 2004, but produced in the spring and summer 2003) experienced very favorable hydrologic conditions. This was driven mostly by the high max/min ratio and low summer alteration experienced during water year 2004, the first year in which the freshet was delivered. However, YCT performance was very poor, and thus the 2004 data point falls furthest from the predicted index line of any point in the data set. This large deviation could be due to confounding effects of rainbow trout spawning stock or to tributary conditions, neither of which were incorporated into the indices. However, the 2005 data point - which reflects the first recruit class experiencing the freshet management in both its year of spawn (2004) and its second summer (2005) - fell very close to the line and had the highest YCT index recorded since 1999. This initial response to our flow management suggests that it may have been successful in reversing the invasion of rainbow trout (steady decline in the YCT index) that has been occurring since the mid-1980s.





Calculation of South Fork Snake River Indices

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The Yellowstone cutthroat trout index was calculated using rainbow trout (RBT) and cutthroat trout (YCT) recruitment parameters estimated in the Conant electrofishing reach during recruitment years 1986-2003. These parameters, based on age 1 or yearling fish electrofished in the fall, are assumed to reflect overall recruitment into the upper South Fork Snake River fishery above Heise. Recruitment values for years in which population estimates were unavailable were back-calculated by following cohorts through the population using observed mortality rates. This resulted in data for every year in the range 1986-2003 except 1987. The recruitment parameters calculated were:

YCT	Estimate of yearling YCT abundance
RBT	Estimate of yearling RBT abundance
%YCT	Percent yearling YCT in catch (as a fraction) out of all trout yearlings
%RBT	Percent yearling RBT in catch (as a fraction) out of all trout yearlings
YCT/RBT	Ratio of %YCT in catch to %RBT in catch (estimate of #YCT/#RBT)
YCT/(YCT + RBT)	Percent yearling YCT in catch (as a fraction) out of all <i>Oncorhynchus</i>

Abundance estimates were made using the maximum likelihood method for mark-recapture data. Each parameter was then scaled by subtracting its mean and dividing by its standard deviation over the sampled years. A Kolmogorov-Smirnov test was then used to test the null hypothesis that the sample of each variable came from a population that was normally distributed with mean 0 and variance 1. The null hypothesis could not be rejected for all six variables. Next, we determined the largest subset of the six variables whose members had correlations among each other of $r^2 < 0.5$. This set contained YCT, RBT, and %YCT and was considered to be the best set of uncorrelated variables on which to base an index of YCT status. The eliminated variables were moderately to highly correlated with one another and with %YCT. Principal Components Analysis (PCA) was then performed on the subset of three to determine the linear combination of the YCT, RBT, and %YCT that resulted in the highest differentiation among the 1986-2003 data points. The resulting linear combination, along with a translation (constant) term to make the value strictly positive, thus provided an index of overall strength of YCT recruitment in the South Fork. The coefficients thus determined were rescaled by dividing by the standard deviations to produce coefficients to be applied to the recruitment variables in their original units. The resulting YCT index is:

$$YCTIndex = 3.083 \times 10^{-4} (YCT) - 2.359 \times 10^{-4} (RBT) + 2.559 (\% YCT) + 0.1$$

where %YCT is expressed as a fraction rather than as a percent (e.g., 0.1 instead of 10%).

The hydrologic index was developed from a set of eight hydrologic variables describing hydrologic conditions in the mainstem South Fork as measured at the Heise gage. These eight variables were chosen from a set of 29 such variables (see Moller and Van Kirk 2003) by performing simple and multiple linear regression of YCT, RBT, %YCT, and YCT/RBT, respectively, as functions of the hydrologic variables. Of the 29, all hydrologic variables that appeared with regression coefficients significantly different from 0 in one-, two- and three-variable regression were selected. The resulting group of eight variables thus represented hydrologic conditions that explained variability in the various recruitment variables across the time period 1986-2003. These eight hydrologic variables were:

Spawn alt	Mean daily absolute hydrologic alteration over the spawning period
Spawn max/min	Ratio of maximum during spawning to previous winter minimum flow
1 st growth alt	Mean daily absolute hydrologic alteration over the 1 st summer
2 nd spring alt	Same as spawn alt but calculated over the spring of the fish's second year
2 nd spring datemax	Date of maximum flow during the fish's second year
2 nd spring max/min	Same as spawn max/min but calculated over the fish's second spring
2 nd growth alt	Same as 1 st growth alt but calculated over the fish's second summer
2 nd WY alt	Mean daily absolute hydrologic alteration over the water year in which the fish was sampled as a yearling (1 year old plus a few months)

From this set of eight, 2nd growth alt was eliminated because it was highly correlated ($r = 0.999$) with 1st growth alt. The remaining variables were scaled and tested for normality as described above. All variables were found to be normally distributed from the K-S test results. Canonical correlation analysis (CCA) was then performed with the YCT status index as the dependent variable and this set of seven hydrologic variables as the independent variable vector. In this special case of one dependent variable, CCA determines the linear combination of the independent variables that results in a single index of maximum correlation with the dependent variable. A backwards stepwise procedure was used to eliminate variables to obtain the best correlation. Initially, all seven independent variables were included, and we recorded the P -value associated with the null hypothesis that the dependent variable is not a linear function of the linear combination of the independent variables. At each step, the variable with the smallest coefficient absolute value in the linear combination was eliminated and the process repeated until the null hypothesis could be rejected with the smallest P -value. The resulting linear combination, along with a translation (constant) term to make the value strictly positive, thus provided an index of hydrologic conditions positively correlated with the YCT index. The coefficients thus determined were rescaled by dividing by the standard deviations to produce coefficients to be applied to the hydrologic variables in their original units. The resulting hydrologic index is:

$$\text{Hydroindex} = -5.051(\text{spawn alt}) + 0.1818(\text{spawn max/min}) - 1.742(1\text{st growth alt}) \\ + 0.1363(2\text{nd spring max/min}) - 3.183(2\text{nd spring alt}) + 4$$

Not surprisingly, this index reflects the conclusions made in Moller and Van Kirk (2003) that favorable conditions for YCT relative to RBT occurred when hydrologic alteration was low and max/min ratios were high during the year in which the fish were spawned and reared. In addition, the index shows these same dependences (although weighted somewhat less) on hydrologic conditions during the fish's second year of life. The YCT index was significantly positively correlated with this hydrologic index (see above figure, $P = 0.0239$, $r^2 = 0.645$).

After determining this hydrologic index, we performed an identical procedure starting with a set of 10 independent hydrologic variables that included the seven used above plus three additional variables measuring hydrologic conditions in the South Fork spawning tributaries (combined discharge) that were identified during the regression analysis as having significant effects on YCT/RBT, which was the only recruitment variable depending significantly on tributary hydrology. These three independent variables were:

Tspawn mean	Mean discharge in tributaries during spawning season
Tgrowth max	Maximum discharge in tributaries during the fish's first summer
Tgrowth mean	Mean discharge in the tributaries during the fish's first summer.

During the stepwise elimination process, all three of these variables were eliminated, leaving the same linear combination as was obtained above. Thus, we infer that the YCT index is less sensitive to hydrologic conditions in the tributaries than in the mainstem, despite significant dependence of the single variable YCT/RBT on tributary hydrology. It is possible that if YCT/RBT had been retained in the development of the YCT index, the tributary dependence would have appeared in the hydrologic index. However, the correlation of YCT/RBT with other recruitment variables led to multicollinearity in the PCA

used to determine the YCT index, thus making its inclusion statistically invalid. So, we determined that the YCT and hydrologic indices given above represent the best metrics on which to base success of flow management at Palisades Dam in increasing the overall status of YCT relative to RBT.